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ScienceDirect

Procedia Computer Science 102 (2016) 202 – 208

Procedia Computer Science

12th International Conference on Application of Fuzzy Systems and Soft Computing, ICAFS 2016, 29-30 August 2016, Vienna, Austria

The use of computer controlled line follower robots in public transport

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Abstract

There is a need for technological reform and innovation in public transport because of the increasing number passengers. In order to ease up the problems arising from the increasing number of passengers, the number of services can be increased and the transit times between stops can be shortened, which result in drivers' weariness and speeding leading to accidents. For that reason, the integration of technology to public transport becomes a must to prevent such accidents. This study aims to investigate "the use of computer controlled line follower robots in public transport".

Peer-review under responsibility of the Organizing Committee of ICAFS 2016

Keywords: Line follower; public transport; mobile-connected vehicles; automatic guided vehicles.

1. Introduction

The aim of the study is to provide passengers with comfortable, fast and off-peak public transportation that is not time-consuming in order to minimize the use of private vehicles. With the invention of line following property, vehicles can drive properly. The number of accidents has been reduced thanks to the connection with the host system maintaining information exchange in terms of road conditions and monitoring the vehicle continuously. With the help of the sensors placed on the vehicle, it is possible to store data and exchange information instantly, such as weather and road conditions, general information about the vehicle, the stops, the speed it should follow, the angles and speeds it should have while taking the bends. In case of disconnection with the center, the users are able to

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Peer-review under responsibility of the Organizing Committee of ICAFS 2016
doi:10.1016/j.procs.2016.09.390

utilize all of the map information loaded beforehand. This study aims to reduce the traffic jam, the time spent on the roads, the pollution and the number of drivers. The newly developed system is based on vehicle – to – infrastructure (V2I)[1] communication system.

1.1. Importance of the study

Mobile robots, is the form of vehicles are able to move along the lines in the roads specially designed as they are taught to follow lines, thus creating a continuous flow in public transport traffic as the robots cannot go out of the roads assigned to them. These robots will be in touch with the host system using the communication modules sending instant data for road condition and the vehicle's current state. Hence, the operator at the host will be able to access the information about the vehicle's current state, temperatures, moisture, speed, location, curves, stops and whether there are objects in front of the vehicle and the distance between the vehicle and the object in meter. The data sent from the vehicle will be analyzed by the operator and used to prevent the possible dangers. The vehicle having the information of a coming curve will slow down to the speed defined before and then accelerate to the speed it had before. This study is important as it has the potential to prevent the accidents arising from the drivers and pedestrians. For example, drivers working in public transport can sometimes drowse off due to the busy and monotonous working hours. Pedestrians crossing the roads carelessly and various objects standing on the roads going unnoticed by the drivers can result in accidents involving death. This study contributes to reducing the potential of risks on the roads by detecting them beforehand.

Numerous studies have been conducted since the word "robot" was coined[2]. Line follower robots[3] have been used in industrial logistics[4]. Low cost line following system[5] and leader and slave robots were designed to do more than one heavy-duty[6]. On the other hand, robots with digital cameras have been used in mines[7], while probes with ultrasonic sensors controlled with fuzzy logic are used in research and rescue operations[8], and educational purpose[9] as well. General purpose robots development are still being conducted[10,12].

1.2. Current technologies

Arduino robot with Atmel ATmega32u4 microcontroller and Arduino UNO REV3 with Atmel Atmega328P microcontroller was used in our study. Moisture and temperature sensors compatible with Arduino sensors, rain sensor, communication module, HC-SR04 distance sensor, K1208040 model infrared speed sensor, light sensor, CNY70 line sensor and RFID labels[13] were used.

1.3. RFID module

Telecommunication is possible with the use of UHF and SHF radio waves are used in a RFID system[14,16]. RFID systems can make use of HF[17,18] or LF[19,20] band electromagnetic induction. RFID reader is RC522 card compatible with Arduino. RC522 RFID card is a small sized card with low energy consumption that can read and write on UHF tag working on 13,56 MHz frequency with NFC frequency. It can be used with many microcontroller platforms, particularly Arduino with a communication speed of 424 Kbit/s. It supports different types of encrypting on RFID. While LF or HF technologies are used in close-range applications, UHF technologies are used to define object identification in logistic applications[21,24], and service robots[25] are used in health applications[26].

1.4. I2C function

There are many standards for wired rapid communications in digital systems. SPI and I2C can be given as examples[27]. Although the maximum speed they can reach differs, the end number used by the standards with I2C protocol can make the rapid data flow possible. Various peripheral devices that work together and communicate with each other periodically can communicate with the use of minimum number of hardware. As it supports addressable communication protocol, it is easy to make more than one devices communicate with I2C.

2. Materials and method

2.1. Limitations to the study

Changing the present public transport system with the one that is the subject of this study is a difficult period. The first challenge that we will face when we decide to change the system will be the replacement of the former vehicles with the new ones as the vehicles controlled by drivers are used currently. In this study, the vehicles that are planned to be used are robots with computer interaction. In the short run, it looks like a huge financial burden. However, in the long run, a more comfortable and less busy public transport system functioning properly beyond compare will manifest itself repaying the efforts and the money spent.

Another limitation to the implementation of the study is to construct the roads that the line following public transport robots can move along. Also, the project will only be implemented in main roads in the beginning primarily because of the busy roads. If the public transport vehicles and the others use the same lines, the special lines will be damaged resulting in delays and disorders. In this case, there will be no difference between the "Use of computer controlled line follower robots in public transport" and the current public transport system.

A possible disconnection from the host communication unit will also result in some problems. In case of a disconnection between the autonomous robot and the host, offline drive mode will be activated instead of the online drive mode. If the offline drive mode is needed, all of the data related to the route will be saved to the memory unit. So, in case of a disconnection, the robot will retrieve the saved information and decide based on its memory; but offline mode will not be used if connection to the host is available.

2.2. The method used for the formation of the study

2.2.1. Teaching the arduino robot to follow lines

With the traditional HF band short-range RFID systems[28,29] and the antennae placed on the mobile robot, it can detect the labels on the ground. Line follower mobile robot can identify the color of the ground and whether there are lines on the ground or not thanks to the line sensors moving along the lines upon the commands. There are 5 CNY 70 model line detection sensors placed on the Arduino Robot that was used in this study. To follow the lines, 3 line detection sensors placed in the middle were used in this study.

Line detection system in this study works as follows; CNY 70[30] line following module consists of 2 pieces one of which sending light out and the other checking whether the light reflect or not. In order to understand whether there are lines on the road, light is sent to the ground with CNY 70. If the ground is white, the sensor reflects white light, thus the light sent by the sensor reflects on the module again and the robot decides that there are no lines on the ground. If the ground is black, the light sent by the sensor is absorbed and not reflected and the robot decides that there are lines on the ground. After it detects the lines, it performs the tasks assigned by the operator.

When it is on, a value between 0 and 1024 integer appears on CNY 70 sensor. If the detection of a line is not performed, this value will be closer to 1024. If line detection is performed, this sensor gives a value that is closer to 0. The tests conducted during the study showed that the value is between 300-450 when the line detection sensor detected a line; on the other hand the value was found between 900 and 1000 when there are no lined detected by the sensor. Therefore, a set value was determined and assigned as 500. If the lines are detected on the ground, motors can be assigned the tasks at desired speeds and directions.

2.2.2. Formation of the route platform

As shown in Fig. 1., a route platform that long enough to read the stop data and to retrieve data from the sensors assembled on Arduino robot was formed. A number of tests were conducted to obtain data from the sensors on the route and they were proved to be successful. RFID labels were placed on each stop and speed control points and speed and stop data were transferred to the host computer.

2.2.3. Formation of the interface for communication

Line follower public transport vehicles send data instantly to the host computer while they are moving on the designated route. A user interface is needed for the operator to interpret the data. C Sharp (C#) programming language is used for the communication between the operator and the vehicles designated with computer interactive

line follower robots. First interface includes, user log in, status screen which enables the operator to read the instant data, operator adding page by which new operators can be added to the system, tool adding page which helps to add information of the new robots included in the system, vehicle properties page providing all the information of the vehicles and settings page giving access to all those pages.

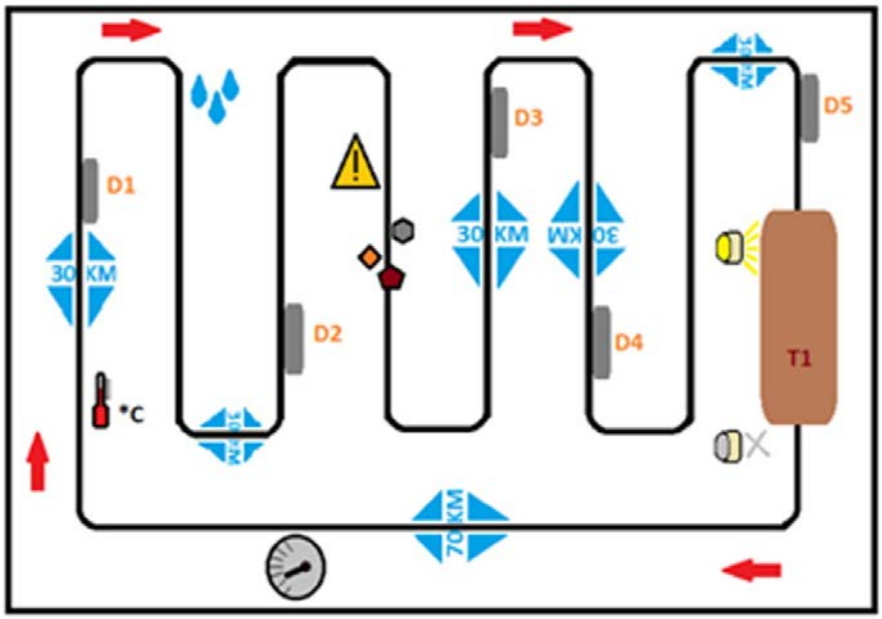

Fig. 1. Route platform

2.2.4. Status screen

This screen shows the instant data of the robot to the operator. This screen provides the information of connection port, date and time, average temperature and moisture, card ID of the RFID card read by the robot and the status information given to that card, the speed of the robot, current and next stop, the vehicle working at that moment and its current status, current vehicle and next vehicle information, rain, the distance of the vehicle from the objects in front of it, if there are any, possible dangers, road map and curve angles.

In order to form a connection between the robot and to get data instantly, a Bluetooth connection (mobile data) is formed on a suitable port on the computer. Second interface show, a port suitable for the connection is chosen among the ones listed on the status screen.

After the port suitable for the connection is chosen, a Bluetooth connection is formed and environmental data and the data concerning the vehicle are transferred to the computer. The operator is warned by instant information in case of high temperatures and moisture levels or an object less than 10 centimeters close to the vehicle. Third interface show, when the “operator settings” button on the status page is pushed, the menu where the Add Operator, Add Vehicle, Vehicle Properties can be configured. When the operator adding button is pushed, operator adding page opens where a new system user can be added to. The new operator’s name, surname, identification number, phone number, type of certificate and the information about the vehicles that the new operator can drive are required on this page with save, delete, approve, clear, edit, search, help and exit buttons and a DataGridView.

When the “Add Vehicle” button is clicked, it opens the page where you can insert the information of a new vehicle. Forth interface show, the properties of the vehicles only.

When you click the “Vehicle Properties”, the properties of the vehicles registered to the system appear on the screen.

3. Analysis and evaluation

After establishing the connection, extracting data from the sensors, teaching the robot to follow lines, forming the route platform, computer interactive line follower public transport robot was ready for implementation. After the robot was put to test, it drove past D1, D2, D3, D4, D5 stops respectively. Although there were no passengers at the stops, the robot was awaited for some time by the operator at each stop. If there are no passengers, the robot will keep going after waiting some time, if there are passengers, it will wait them to get on.

On the same route, the robot transmits the instant information of temperature, moisture and speed to the host computer from the starting point. By help of the RIFD sensor on Arduino Robot, the speed of the robot can be limited by placing RFID UHF tag in the intended area as the RFID reader placed under the robot will read those tags and the robot will slow down.

When the robot starts to work, rain, distance and light sensors will also be activated. The operator will be informed whether it rains or there are any objects in front of the vehicle or it is dark or not helping to take necessary precautions eliminating risks.

At the entrance of the T1 tunnel on the route, the light sensor will inform the host computer that it is dark, the headlights will be activated. At the exit, the light sensor will inform the host computer that it is not dark; and the headlights will be shut down.

The number of accidents will decrease because of the constant and instant communication between the host computers and the robots used in public transport. Also, all of the public transport vehicles will move on smoothly because of their line following property making a faster and more comfortable public transport service possible.

After the session starts, the autonomous robot will retrieve local maps from route data base and speed, curve, stop and tunnel information from the database that includes tag information. Thanks to this information, the robot will be able to move on even if it cannot connect to the operator, which we call unilayer location system. If the robot heads toward the central station with unilayer location system, it can check for the updates again. These assumptions reflect the unilayer movements of the robot, that is, this system forms an extra control mechanism. However, the robot will stay in touch with the host control with the double layer location system while the unilayer location system is a reserve. The stages of the system can be summarized as shown in Fig. 2.

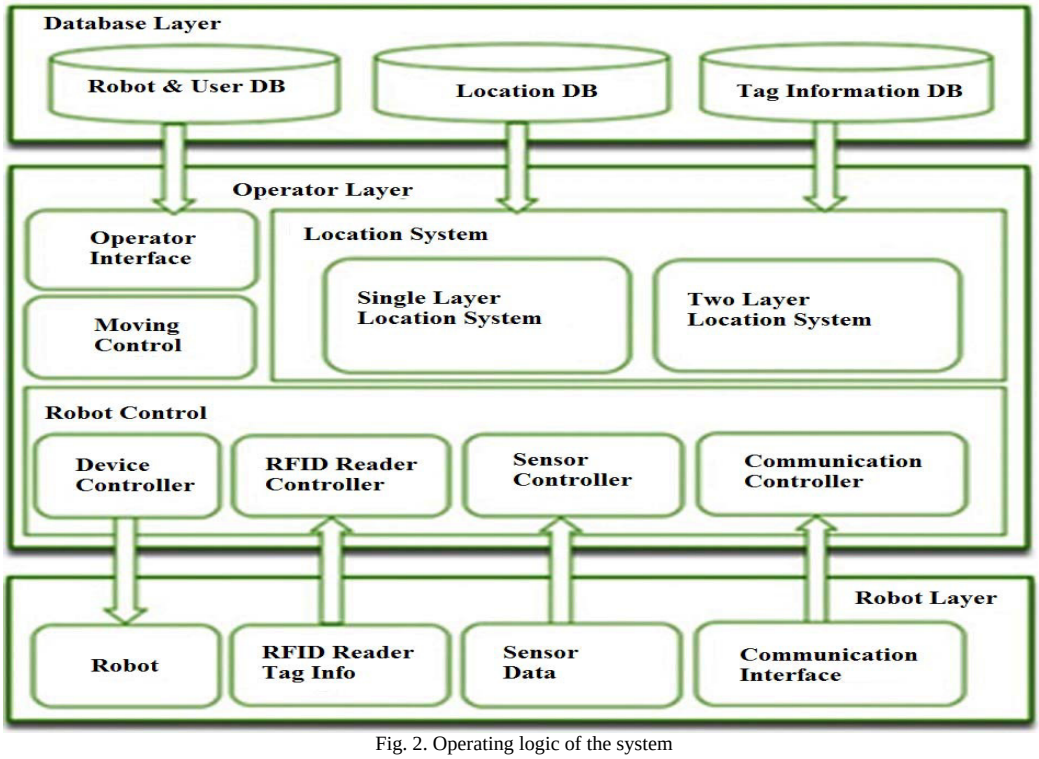

Fig. 2. Operating logic of the system

4. Conclusion

The sensors placed on the autonomous robot can send the environmental information successfully to Arduino UNO. Arduino UNO conveys the data retrieved from the sensors with the communication module to the host computer informing the operator about the current environment. Although we used Bluetooth module in our study, Bluetooth, wireless or mobile network technologies can be used as communication modules. In order to facilitate the use of the robot by the operator, a user interface was written. Because the data transmitted to the computer is digital, it is impossible for the operator or users to understand it.

This prototype implies that the number of traffic accidents can be minimized with the use of computer interactive line follower robots in public transport. With the use of computer interactive robots in public transport, the problems such as snoozing drivers because of the stressful and busy work hours will be eliminated. The system designed as a prototype retrieves tag descriptions, location and robot information via the database. Robot control layer, graphical user interface, movement control system and double layered location information system were used. The autonomous robot can determine the speed, curves and stops thanks to the tag information hidden on the ground. The trials and tests done during the study showed that the computer interactive robots are faster to react to the environmental changes with more control over the risks than the public transport drivers.

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